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VISCOSITY MEASUREMENTS OF FOUR ASBESTOS TAILINGS/SAND MIXTURES

by

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ABSTRACT

Four mixtures of asbestos tailings and low-grade sand were prepared for viscosity measurements using a high-temperature viscometer. Viscosities varying from 3.65 to 0.065 Pa.S were obtained for the temperature range 1340°C to 1620°C. The results show that viscosity can be modified, i.e. increased, by the addition of sand containing a high content of silica. The change of viscosity can be interpreted by the breakdown or build-up of the silicate network structure in the melt.

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INTRODUCTION

CANMET is conducting a research project in thermal insulation in line with EMR's policy of promoting conservation of energy and materials. A main objective of this project is to determine the process parameters and improve the technology for mineral-wool fabrication. Melt viscosity is an important parameter in determining the spinability of the melt and the quality of mineral wool produced (1,2). A high-temperature viscometer was set up for measuring the viscosity of materials selected as charge samples for later experimental mineral-wool making (3).

CANMET has developed a process for the production of mineral wool from asbestos tailings (4) and La Société National de l'Amiate (SNA) is currently conducting further work to determine the commercial feasibility of this process. As a contribution to this effort, CANMET measured the viscosities of four mixtures of asbestos tailings and low-grade sand supplied by SNA.

EXPERIMENTAL WORK

SAMPLES

Table 1 lists the chemical compositions of the asbestos tailings and sand, and the mix proportioning and calculated compositions of the four mixtures.

About 130 g of sample were required. Each sample was calcined at 100°C before viscosity measurements.

A Leitz Heating Microscope type II A-P was used to determine the melting behaviour of the raw materials and the four mixtures. A series of photomicrographs were taken during the heating of a small specimen to a maximum temperature of 1570°C in air. The shrinkage and change of the image of the specimen indicate the thermal behaviour of the sample. The results for the asbestos tailings and sand are shown in Fig. 1 and for the four mixtures in Fig. 2. Figure 1 shows that the asbestos tailings are quite refractory with a softening temperature at about 1570°C, whereas the sand sample begins to melt at around 1380°C. The comparison between the photomicrographs of the four mixtures in Fig. 2 indicates that the melting point increases proportionally with the content of asbestos tailings.

Table 1 - Chemical composition of sample

Sample	Mix proportion wt % asbestos tailings	Mix proportion wt % sand	wt % total SiO_2	MgO	Al_2O_3	Fe	CaO	Na_2O	K_2O	MnO	LOI
Asbestos tailings	100	-	38.77	38.94	na	5.59	na	na	na	na	13.01
Sand	-	100	74.4	1.0	13.1	2.60	2.38	0.04	2.41	0.09	1.8
1	40	60	66.1	17.8	8.6	4.2	1.6	0.02	1.6	0.05	-
2	50	50	63.1	22.3	7.3	4.6	1.3	0.02	1.4	0.06	-
3	60	40	60.0	26.9	5.9	5.0	1.1	0.02	1.1	0.05	-
4	70	30	56.8	31.7	4.5	5.4	0.8	0.01	0.8	0.03	-

LOI - loss on ignition at 1200°C

na - not analyzed

VISCOMETER

The high temperature viscometer system is shown schematically in Fig. 3. It consists of (a) an induction furnace (b) a viscometer incorporating a variable speed Brookfield torque meter with a molybdenum crucible and bob and (c) a gas train. Details of the apparatus construction are given elsewhere (3).

Induction heating is used to melt the sample by coupling an induction generator to the molybdenum crucible. The heat loss from the furnace is minimized by placing the molybdenum crucible inside an alumina crucible, the gap between the two crucibles being filled with zirconia grains as insulation. In addition, an alumina tube lined with molybdenum foil is used as a heat shield, and a molybdenum heat reflector plate is placed on top of the alumina tube. The whole assembly is set inside a silica tube which, in turn, is snuggly fitted inside the induction coil. The zirconia grains provide a second useful function - at high temperature, they become semiconductor and when coupled to the induction generator will produce additional heat for melting.

The torque meter is a Brookfield Rheolog type viscosity transmitter, Model RVG, equipped with an 8-speed transmission. The Rheolog sensing head (transmitter) output is fed into a pneumatic - to - electric transducer giving an output of 0-10 mv which, in turn, is fed to a recorder. The viscometer system was calibrated using standard silicone oils. The signal from the transmitter was recorded in terms of millivolts for a given bob rotation speed for each standard viscosity fluid.

The viscosity measurements were carried out under a positive pressure of argon mixed with 1% nitrogen. The nitrogen served to eliminate the ionization (arcing) of the argon gas at high temperature.

VISCOSITY MEASUREMENT

After the sample-filled molybdenum crucible had been properly positioned in the induction furnace, the system was flushed with argon gas for about 5 min. The furnace temperature was then raised to the desired minimum for the viscosity measurement. Once the furnace had reached thermal equilibrium, the bob was lowered into the melt and the torque meter motor started. Viscosity readings were recorded continuously as the furnace temperature was increased to a maximum of 1620°C. The melt temperature was monitored simultaneously by an optical pyrometer through the viewing window. The melt was

then cooled and viscosity readings taken until a solid or crust appeared on the melt. If necessary, the heating and cooling cycle could be repeated.

RESULTS AND DISCUSSION

The viscosity data for the four mixtures are presented individually as a function of temperature in Fig. 4, 5, 6 and 7. The results show that viscosity decreases as temperature increases. It is well accepted that viscosity depends on the size of the largest species in the melt, i.e., the silicate anions. An increase in temperature causes progressive loosening of the silicate network structure by thermal agitation. This action will decrease viscosity.

Melt viscosity also depends on the melt composition. To illustrate this effect, all the data are combined in Fig. 8. The results indicate that the addition of sand to the mixture definitely increases the melt viscosity although this effect of sand content increase from sample 4 to sample 3 does not seem to be significant. Sand contains 74.7% SiO_2 which is a silicate network former. As the silica content of the melt increases, the polymerization of SiO_4^{4-} group and the average size of the silicate anions must increase. The melt becomes more glassy. This is reflected by the rise in viscosity.

X-ray diffraction analysers were conducted on the frozen melts after viscosity measurements. The diffraction patterns obtained for samples 2, 3 and 4 show that the crystalline phases are solid solution of forsterite-fayalite and orthopyroxene, while those for sample 1 show very weak diffraction lines and the phase identified is a solid solution of forsterite-fayalite. The poorly developed diffraction patterns for sample 1, when compared with the other samples, suggest that sample 1 is appreciably more glassy because of the higher sand content.

In mineral wool production, the melt is converted into fibres either by spinners or by a blast of steam or air. The fibres must form within an extremely short period of time when the material remains molten after the melt has been dispersed into fine globues. It is imperative that the molten material, being rapidly cooled, shall pass through a viscous stage before solidification. The greater the melt viscosity range (within certain limits) the bigger the amount of wool produced. Zhilin observed that a good quality fibre

was obtained if the viscosity of the melt was about 0.5 N.S/m^2 (500 centipoise) at 1500°C, or 1.5 N.S/m^2 (1500 centipoise) at 1400°C, (5). The viscosity data in Fig. 8, following the above argument, indicate that sample 1 and 2 could produce acceptable fibres.

CONCLUSIONS

The relationships between viscosity, temperature and composition for four asbestos tailings - sand mixtures were investigated at temperatures up to 1620°C. The viscosities ranged from 0.065 to 3.65 Pa.5. Viscosity, in general, increases as the sand content increases. The viscosity data suggest that sample 1 (60% sand - 40% asbestos tailings) and sample 2 (50% sand - 50% asbestos tailings) are suitable for mineral wool making.

ACKNOWLEDGMENT

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REFERENCES

1. Schubert, P., Harper, P.H.I. and Barham, D. "Criteria involved in the prediction of spinability of mineral wool"; J Can Ceram Soc 48:17-22; 1979.

2. Gillespie, J.E. "The manufacture of mineral wool"; Can Min Metall Bull 41:20-24; 1948.

3. Quon, D.H.H. and Wang, S.S.B. "Investigation of the viscosity-temperature relationship of materials usd for the experimental production of mineral wool; Division Report MRP/MSL 80-109(IR); CANMET, Energy, Mines and Resources Canada; 1980.

4. Winer, A. "Mineral wool insulation from asbestos tailings"; Can Min Metall Bull 67:752:97-104; 1974.

5. Zhilin, A.I. "Raw materials for the production of mineral fibres"; J Appl Chem USSR 23:11:1157-1164; 1950.

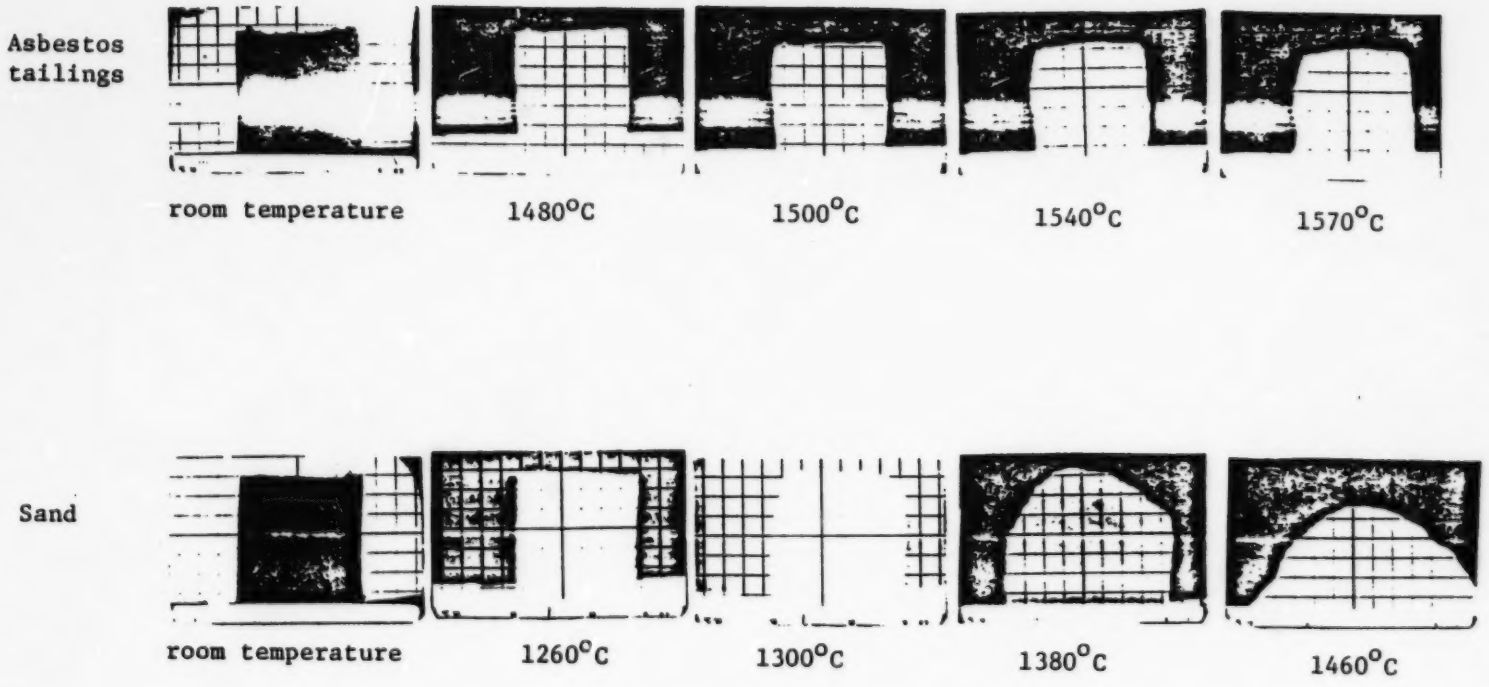

Fig. 1 - Series of photomicrographs showing silhouettes of the asbestos tailings and sand sample

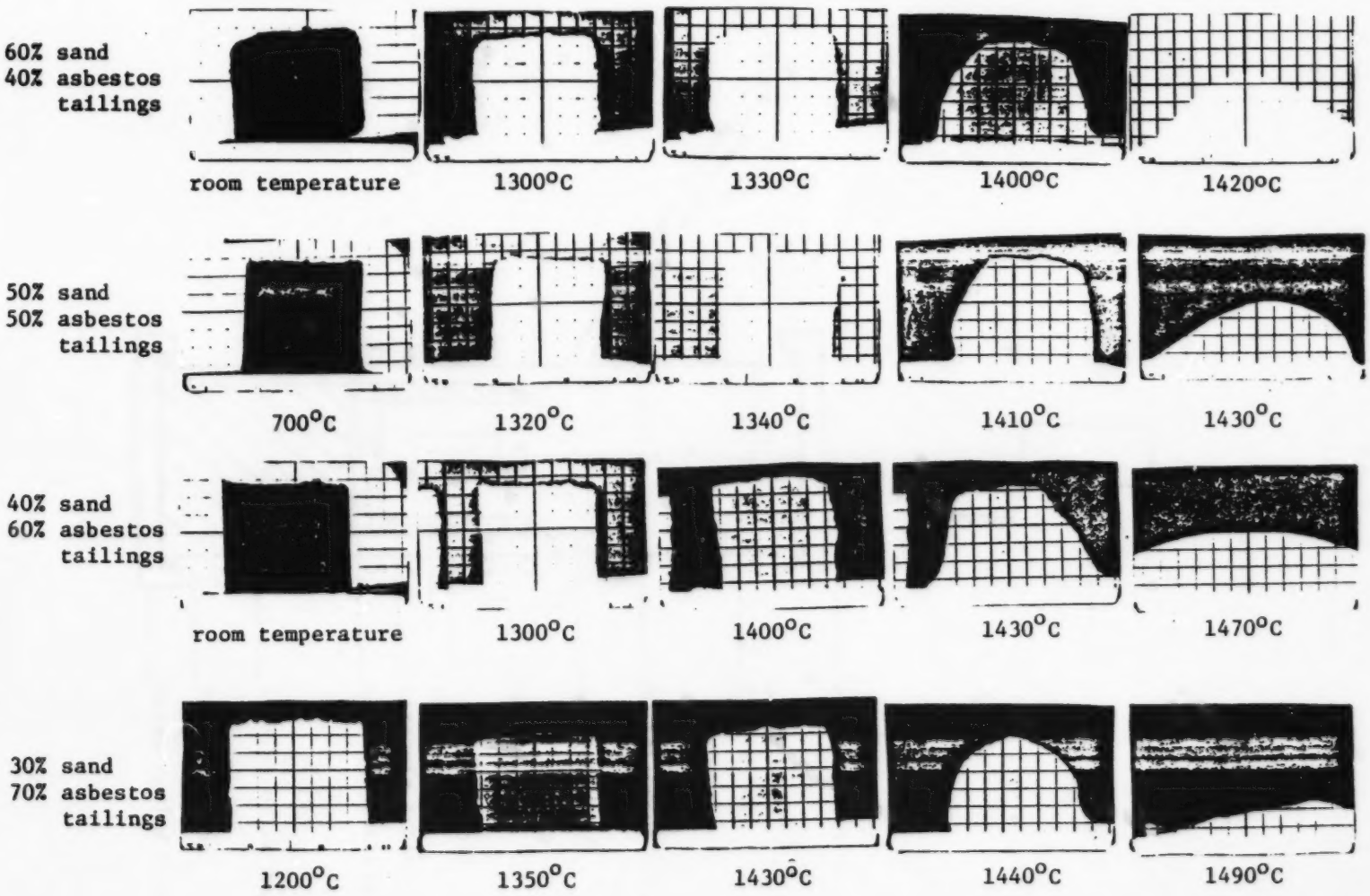

Fig. 2 - Series of photomicrographs showing silhouettes of the four mixtures

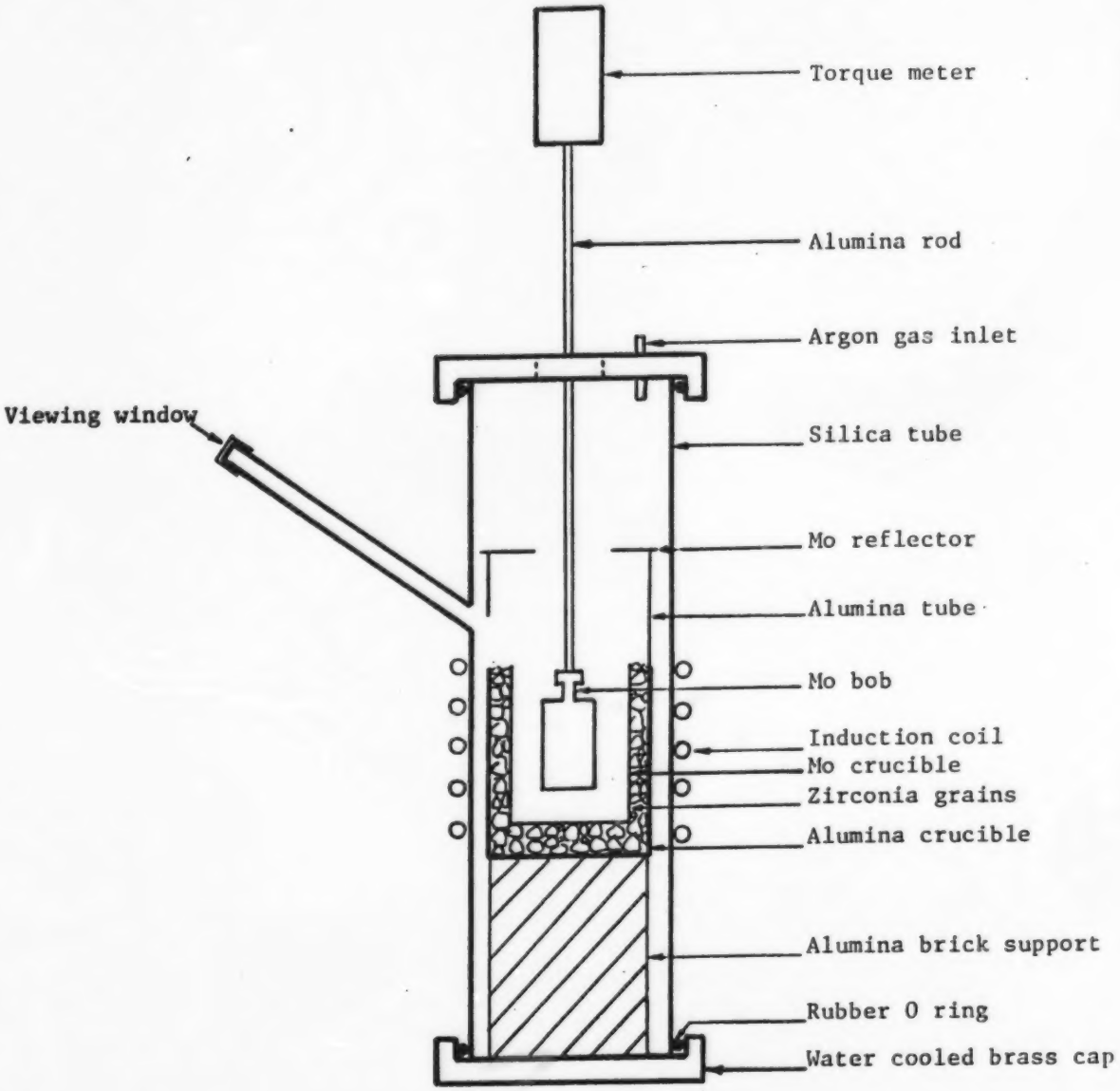

Fig. 3 - The viscometer set-up

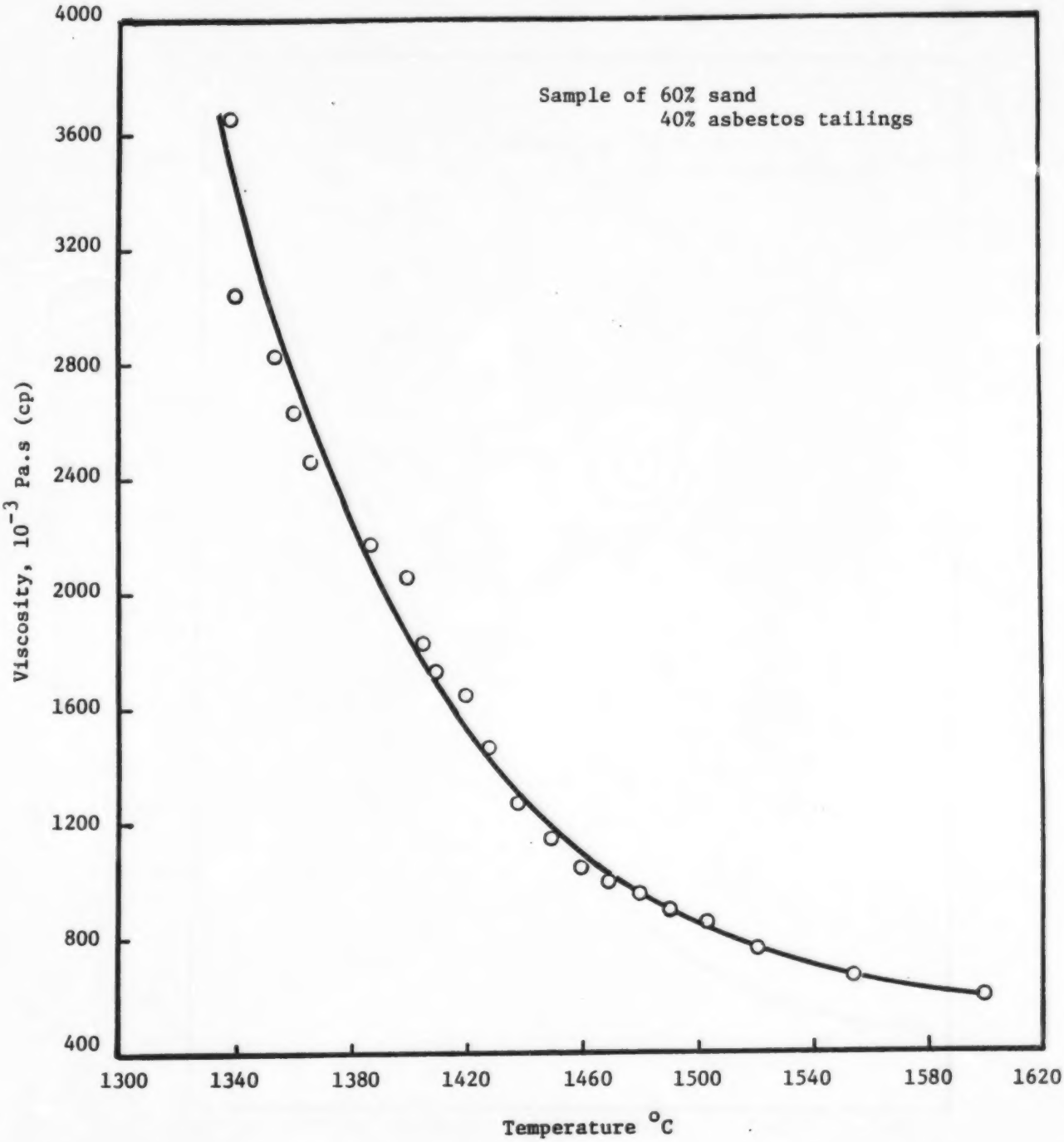

Fig. 4 - Viscosity data for sample 1

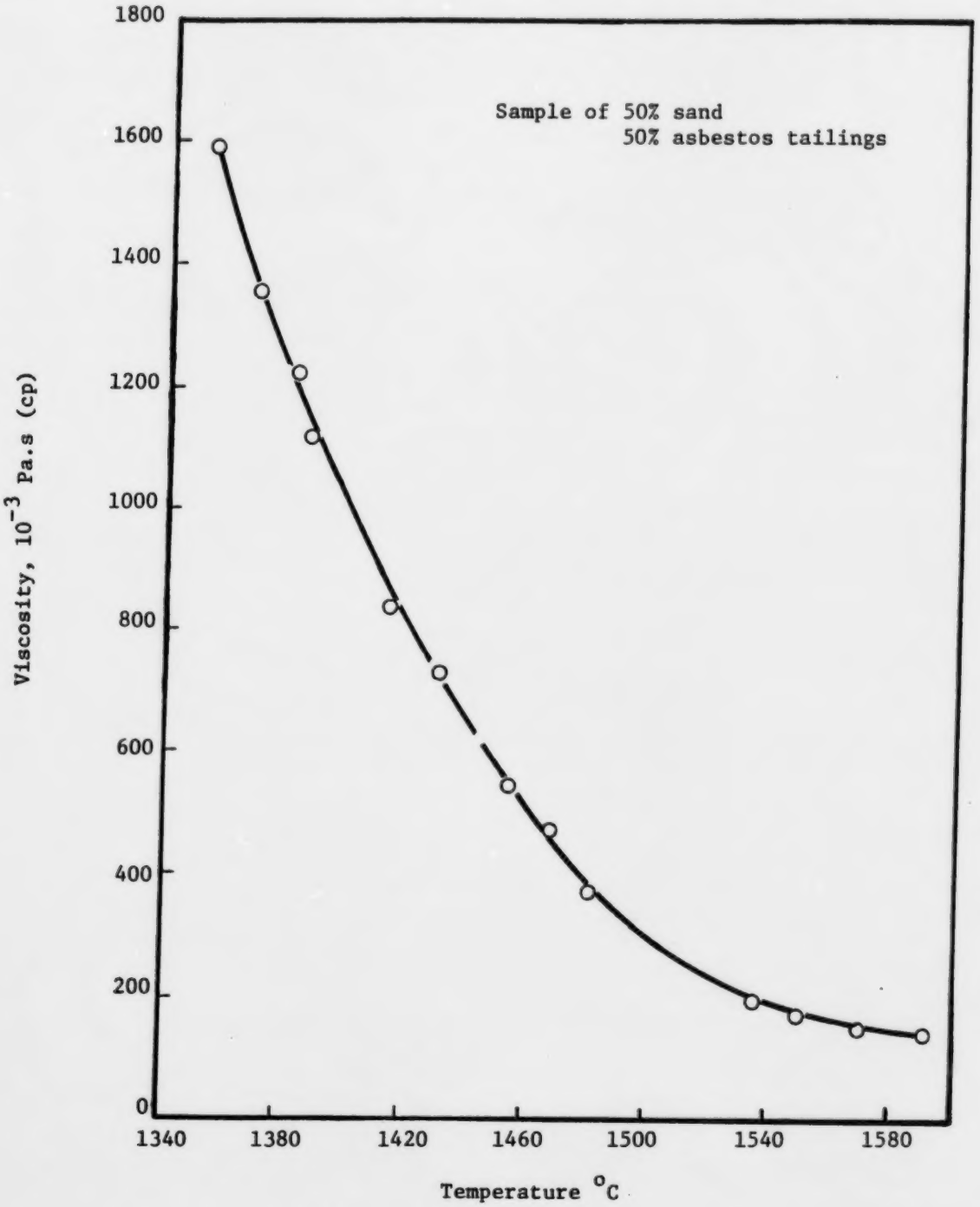

Fig. 5 - Viscosity data for sample 2

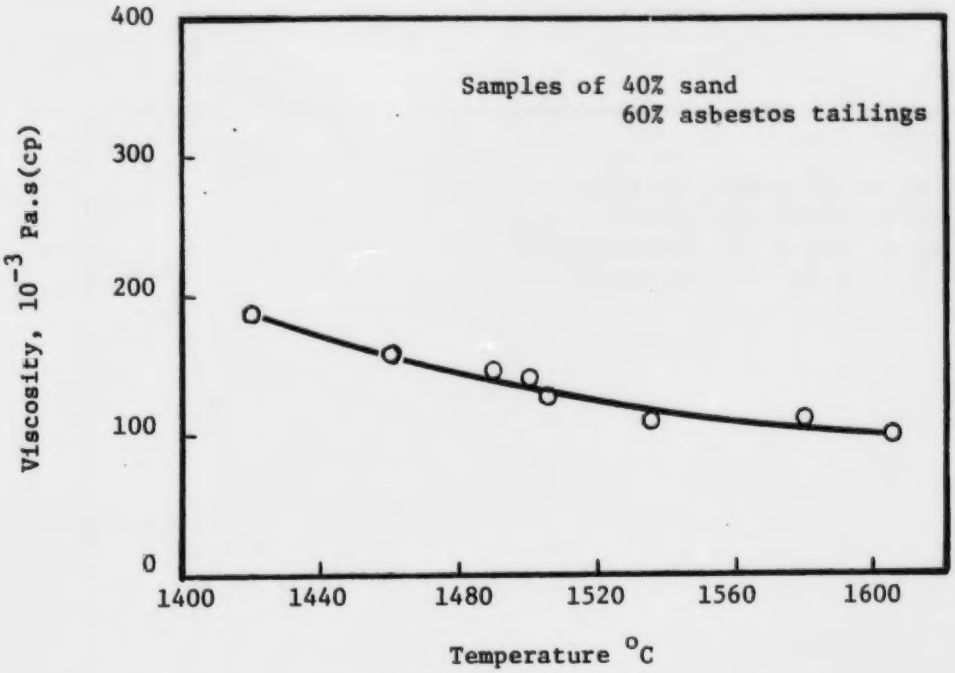

Fig. 6 - Viscosity data for sample 3

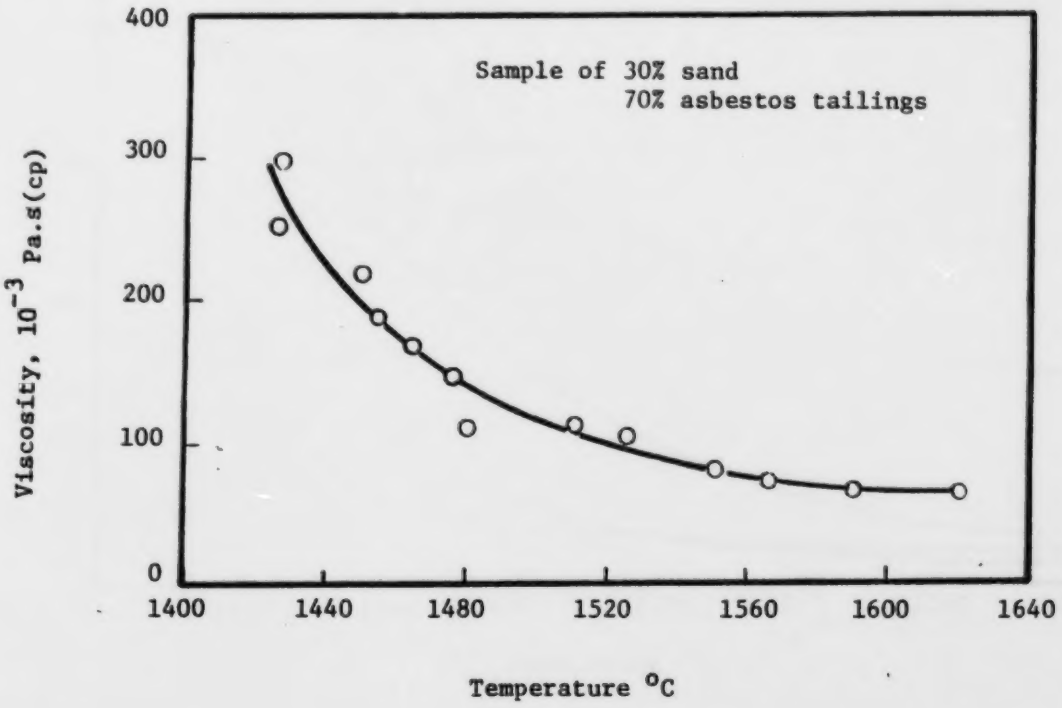

Fig. 7 - Viscosity data for sample 4

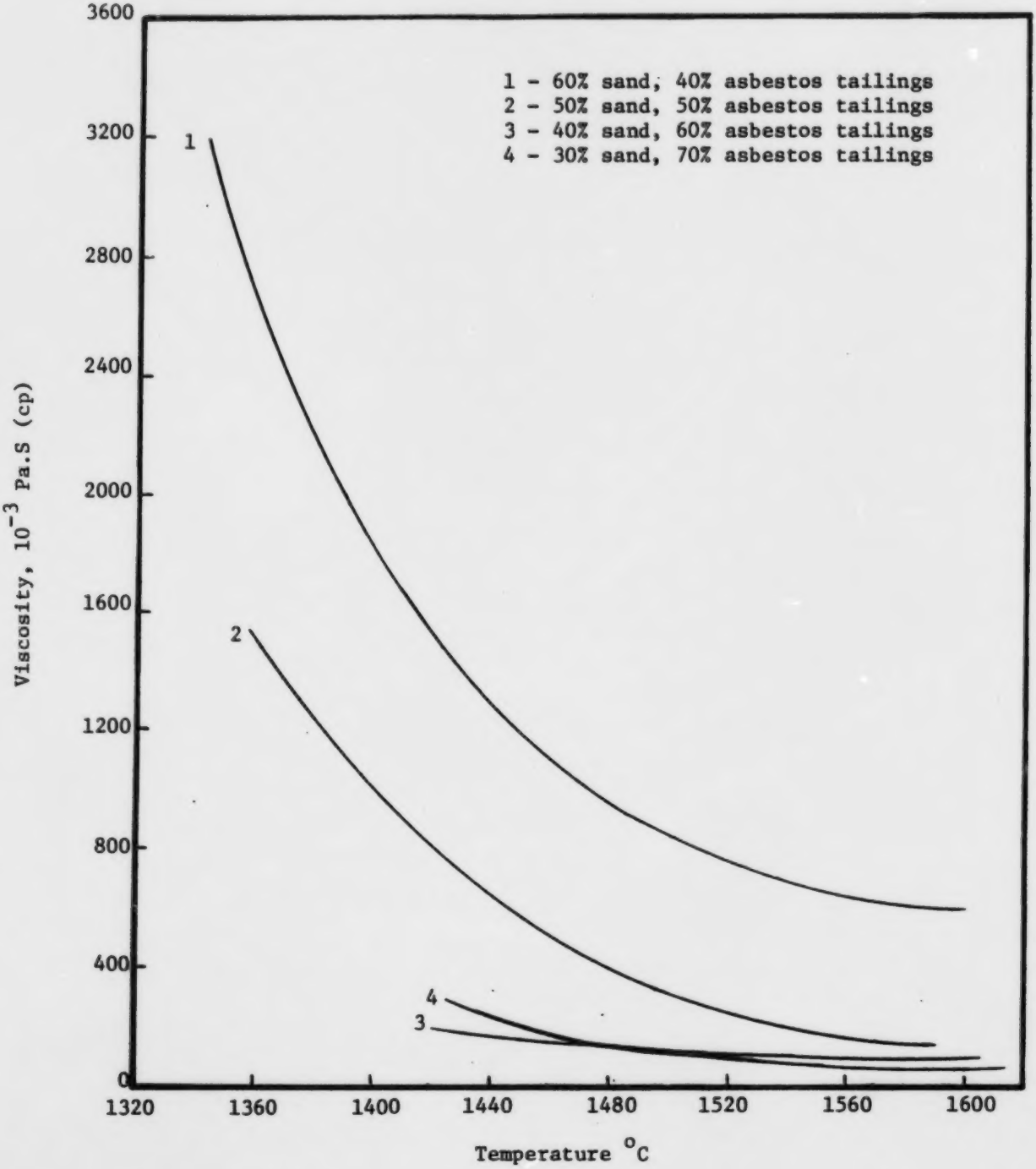

Fig. 8 - Summarized viscosity data for the four mixtures as a function of temperature